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Original Research Article

Association of Anthropometric Adiposity Indices with Anxiety Symptoms in Type 2 Diabetes Mellitus at Ahmadu Bello University Teaching Hospital Zaria, Kaduna State

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ABSTRACT
Anxiety symptoms are common psychological complications among individuals with Type 2 Diabetes Mellitus (T2DM) and may contribute to poor disease outcomes. Anthropometric adiposity indices reflect metabolic alterations associated with diabetes; however, their relationship with anxiety symptoms remains insufficiently explored, particularly in African clinical populations. This study evaluated the association between anthropometric adiposity indices and anxiety symptoms among patients with T2DM attending Ahmadu Bello University Teaching Hospital, Zaria. A cross-sectional analytical study was conducted among 400 patients with T2DM. Anxiety symptoms were assessed using the Generalized Anxiety Disorder-7 questionnaire. Anthropometric indices, including body mass index (BMI), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), body adiposity index (BAI), conicity index (CI), a body shape index (ABSI), biceps skinfold thickness (BSF), and triceps skinfold thickness (TSF), were evaluated. Binary logistic regression was used to assess associations, while receiver operating characteristic (ROC) curve analysis evaluated discriminatory performance. The overall logistic regression model was not significantly associated with anxiety symptom status (Omnibus test: $\chi^2 = 11.294$, df = 7, p = 0.126). TSF showed a significant association with anxiety symptoms (OR = 1.076, 95% CI: 1.009–1.148, p = 0.026), while BSF demonstrated a borderline association. ROC analysis revealed limited discriminatory ability across all indices, with TSF showing the highest area under the curve (AUC = 0.5737, 95% CI: 0.5112–0.6362). Anthropometric adiposity indices alone have limited ability to identify anxiety symptoms among patients with T2DM. Although TSF showed a weak association, psychological, metabolic, and socioeconomic factors should be considered when assessing anxiety risk in this population.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycaemia resulting from insulin resistance and progressive β-cell dysfunction, leading to impaired glucose regulation (Harisu *et al*., 2025). Its increasing global burden is driven by multiple risk factors, including genetic predisposition, physical inactivity, unhealthy dietary patterns, and obesity. The International Diabetes Federation has projected a continued rise in diabetes prevalence worldwide, with substantial implications for healthcare systems. In Nigeria, diabetes prevalence among adults' ranges from 0.65% to 11.0%, with increasing trends attributed to lifestyle changes, limited healthcare access, and inadequate awareness (Olamoyegun *et al*., 2024; Abdulmalik *et al*., 2025).

Beyond its metabolic complications, T2DM is increasingly recognized as a condition associated with significant psychological burden. Chronic disease management, dietary restrictions, fear of complications, and continuous self-monitoring contribute to psychological stress among individuals living with diabetes (Gonzalez *et al*., 2016). Evidence suggests a strong relationship between T2DM and mental health disorders, including anxiety symptoms, which may adversely affect treatment adherence, glycaemic control, and overall quality of life (Basiri *et al*., 2023; Ahmad *et al*., 2022). Metabolic disturbances associated with insulin resistance may also influence inflammatory and neurochemical pathways involved in mood regulation, supporting the interaction between metabolic dysfunction and psychological outcomes (Luo *et al*., 2015).

Anxiety symptoms (AS) represent an important but underrecognized comorbidity among individuals with T2DM. Studies from sub-Saharan Africa have reported a considerable burden of anxiety among diabetic populations, with hospital-based studies in Nigeria reporting substantial prevalence of anxiety disorders among affected patients (Taylor *et al*., 2012). Similar observations have been reported in Ghana, suggesting a regional pattern of psychological vulnerability among individuals with diabetes (Abu Bonsra *et al*., 2015). However, data regarding factors associated with AS among diabetic populations in African settings remain limited.

Adiposity distribution has emerged as an important factor linking metabolic and psychological health outcomes in T2DM. Visceral adiposity, assessed through indices such as waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), conicity index (CI), and a body shape index (ABSI), is metabolically active and associated with insulin resistance, systemic inflammation, and endocrine dysfunction (Wei *et al*., 2019). These inflammatory processes have also been implicated in neuropsychiatric conditions, suggesting a possible relationship between adiposity and anxiety-related outcomes (Wang *et al*., 2022). Conversely, measures of general and subcutaneous adiposity, including body mass index (BMI), body adiposity index (BAI), and skinfold thickness, may influence psychological well-being through metabolic stress and body image perception (Stefanaki *et al*., 2018).

Despite the recognized association between adiposity and metabolic dysfunction, the relationship between specific anthropometric indices and anxiety symptoms among individuals with T2DM remains unclear. Previous research has largely focused on cardiometabolic outcomes, while limited attention has been given to psychological outcomes, particularly within African clinical populations (Geraci *et al*., 2026; Sibal *et al*., 2025; Tanasescu *et al*., 2025). Furthermore, most studies have relied on single measures such as BMI, which may not adequately capture variations in body fat distribution. Evaluating multiple anthropometric indices may therefore provide a broader understanding of the relationship between adiposity patterns and anxiety symptoms.

Nigeria continues to experience a growing burden of T2DM, yet psychological screening is not routinely integrated into diabetes management in many healthcare settings. Consequently, AS may remain undetected, contributing to poorer treatment outcomes and increased healthcare burden. Identifying simple, non-invasive markers associated with psychological vulnerability may support more holistic diabetes care, particularly in resource-limited settings.

Therefore, this study aimed to evaluate the association between multiple anthropometric adiposity indices and anxiety symptoms among patients with T2DM attending Ahmadu Bello University Teaching Hospital (ABUTH), Zaria. The findings may contribute to improved understanding of the interaction between metabolic health and psychological outcomes and support integrated approaches to diabetes management.

MATERIALS AND METHODS

Ethics and Compliance in a Cross-Sectional Study

Ethical approval for this study was granted by the Health Research Ethics Committee of Ahmadu Bello University, Zaria (Ref: ABUCUSHR/2024/017), in accordance with institutional and international research ethics standards. Prior to participation, all respondents provided written informed consent after being fully informed about the study objectives, procedures, potential risks, and benefits. Participants were assured of strict confidentiality, anonymity, and their right to withdraw from the study at any stage without any consequences. Furthermore, the study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies (Mehta and Naveed, 2025), ensuring methodological transparency, completeness of reporting, and adherence to best practices in observational research.

Study Design and Setting

This cross-sectional analytical study was conducted at ABUTH, Zaria, Kaduna State, Nigeria, a tertiary healthcare facility serving a diverse population. The study period spanned from July 2024 to March 2025, during which data were collected from eligible patients attending the endocrinology and diabetes clinic.

Study Population

The study enrolled 400 adult patients (159 miles (39.8%) and 241 females (60.2%)), aged ≥18 years, diagnosed with T2DM according to the American Diabetes Association criteria (Sabo *et al*., 2023). Inclusion criteria included a confirmed diagnosis of T2DM for at least 6 months and the ability to provide informed consent. Patients with severe comorbid conditions, cognitive impairment, or current use of antidepressants were excluded to avoid confounding depression assessment.

Sample Size Determination and Sampling Technique

This formula was used to compute the sample size:

$N = (Z_{\alpha/2}+ Z_{\beta})\ 2\ (P_1(1- P_1) + P_2\ (1- P_2)/ (P_1- P_2)^2$ (Bhardwaj et al., 2024)

Where:

$P_1 = 0.1$ (proportion of AS in T2DM) (Azudialu et al., 2024),

$P_2 = 0.03$ (proportion of T2DM without AS) (Ochigbo et al., 2024),

$Z_{\alpha/2}$ is the critical value for a 95% confidence level (which is approximately 1.96),

Z_{β} is the critical value for an 80% power (which is approximately 0.84).

The calculated sample size is approximately 190 participants per group. To accommodate a 5% attrition rate, an additional 10 participants were included, increasing the total to 200. Participants were subsequently classified into AS-positive and AS-negative groups based on GAD-7 scores, resulting in approximately 200 participants in each analytical category. Patients were recruited using a systematic random sampling technique and screened for eligibility.

Data Collection Procedures

Sociodemographic and Clinical Data

A structured questionnaire was administered to collect demographic information, including age, sex, marital status, family setting, and educational level. The medical history included the duration of diabetes.

Anxiety Symptoms Assessment

AS was assessed using a validated self-administered screening instrument based on DSM diagnostic criteria, GAD-7 questionnaire. Participants reported the frequency of anxiety-related symptoms over the preceding two weeks using a 4-point Likert scale: 0 = “not at all,” 1 = “several days,” 2 = “more than half the days,” and 3 = “nearly every day.” The total score was computed by summing all item responses, with higher scores indicating greater severity of anxiety symptoms.

For classification purposes, scores were categorized into severity levels as follows:

1. 0–4: Minimal anxiety
2. 5–9: Mild anxiety
3. 10–14: Moderate anxiety
4. 15–21: Severe anxiety

In this study, participants were categorized according to AS status based on their GAD-7 scores. Individuals with scores below the selected threshold (0–4) were considered to have minimal anxiety symptoms, whereas those meeting the threshold (≥5) were classified as having clinically relevant AS for analytical comparison. The classification was used for epidemiological assessment and should not be interpreted as confirmation of a formal psychiatric diagnosis. The Cronbach’s alpha for the GAD-7 questionnaire used typically ranges from 0.80 to 0.89, indicating good internal consistency **(**Ibigbami *et al.,* 2023**)**.

Anthropometric Measurements

Anthropometric measurements were taken according to the standard protocols reported by the International Society for the Advancement of Kinanthropometry (ISAK) (Silva and Vieira 2021). Briefly, the measurements were taken as follows:

1. Height (Ht) (m): Standing with bare feet, vertically in the midline from heel to vertex (the topmost position of the head) to the nearest 0.1cm using a stadiometer (Holtain Harpenden, UK).
2. Weight (Wt) (kg): The subjects were barefoot and lightly dressed. Weight was taken to the nearest 0.1 kg using a digital weighing balance (EBSA-20, Kolgon Industrial Limited, China).
3. Waist Circumference (WC) (cm): Distance at the level of the narrowest point between the lower costal (rib) border and the iliac crest. It was measured perpendicular to the long axis of the trunk (cm) using flexible inelastic tape (Luftkin W606PM, NutriActiva Limited, USA).
4. Hip Circumference (HC) (cm): the distance at the level of the greatest posterior protuberance of the buttocks and perpendicular to the long axis of the trunk (cm) using flexible inelastic tape (Luftkin W606PM, NutriActiva Limited, USA).
5. Skin fold thickness (SF): the biceps skinfold was measured vertically on the front of the upper arm, over the belly of the biceps muscle, midway between the acromion and the radial landmarks. The triceps skinfold was also measured vertically on the back of the upper arm, over the triceps muscle, at the same

mid-acromial-radiale level, with the arm relaxed by the side. Measurements were done in mm using a stainless skinfold calliper (Holtain Harpenden, UK).

The following adiposity indices were evaluated from the measured anthropometric variables, viz:

1. Body Mass Index (BMI): Wt (kg)/Ht (m) ^{2} (using 18.5-24.9 to be normal and >25 abnormal) (Nihiser *et al*. 2007).
2. Waist-To-Hip Ratio: WHR (using <0.85 to be normal and > 0.85 abnormal) (Lear *et al*. 2010).
3. Waist-To-Height Ratio: WHtR (using 0.4 - 0.5 to be normal and numbers outside the range as abnormal) (Savva *et al*. 2013).
4. Body adiposity index (BAI) = [HC/ (Ht) $^{1.5}$] – 18. Where: HC is in centimetres and Ht is in meters. (using 21 - 30 as normal and numbers outside the range as abnormal) (Bennasar *et al*. 2013).
5. Conicity Index (CI) = WC (m)/ 0.109× [Wt (kg)/ Ht (m)]$^{0.5}$ (using 1.0 -1.73 as normal and numbers outside the range as abnormal) (Gowda and Philip, 2016)
6. A body shape index (ABSI) = WC (m)/BMI2$^{/3}$×Height (m) $^{1/2}$ (using >0.08 to be normal) (Nagayama *et al*., 2022)

Intra and inter-observer measurement errors assessment

Measurement precision was evaluated to quantify both intra-observer and inter-observer variability following established protocols (Sabo et al., 2024). Technical measurement error was assessed using standard reliability statistics, including absolute technical error of measurement (aTEM), relative technical error of measurement (rTEM), coefficient of reliability (Rr), and coefficient of variation (CV). These metrics collectively provided an indication of measurement consistency, repeatability, and overall methodological reliability in anthropometric data acquisition.

To calculate aTEM, the following formula was applied:

1. aTEM = $\sqrt{\Sigma}\,(m_1 - m_2)^2 / 2n$
   Here, ‘n’ represents the number of participants being measured, while ‘m_1’ and ‘m_2’ correspond to the first and second measurements.
   Subsequently, rTEM was computed using the formula:
2. rTEM = (aTEM / VAV) × 100
   Where ‘VAV’ signifies the variable average value, essentially the mean of the two measurements.
   The calculation of Rr involved the following formula:
3. Rr = 1 – (aTEM^2 / SD^2)
   In this equation, ‘SD’ is the standard deviation of all measurements.
   Finally, Cv was determined using the formula:
4. Cv = (SD * 100) / X
   Where ‘X’ represents the mean of all measurements.

Data Analysis

Normality of the data was assessed using the Kolmogorov–Smirnov test. Descriptive statistics were presented as mean ± standard deviation for continuous variables and as frequencies and percentages for categorical variables. Baseline characteristics between T2DM patients with and without AS were compared using Pearson’s chi-square test for categorical variables.

Binary logistic regression analysis was performed to examine the association between anthropometric indices and AS status. Odds ratios (OR) with 95% confidence intervals were calculated to estimate the strength and direction of associations. ROC curve analysis was conducted to evaluate the discriminatory ability of anthropometric indices for identifying AS status. All statistical analyses were performed using SPSS version 28 (IBM, New York, USA), with statistical significance set at $p < 0.05$.

RESULTS AND DISCUSSION

The absolute and relative technical error of measurement (aTEM and rTEM), coefficient of reliability (Rr), and coefficient of variation (CV) for all anthropometric variables, assessed for both intra- and inter-observer variability, were within acceptable methodological limits, indicating high measurement precision and consistency. Accordingly, the detailed precision results table is not presented.

Participant Characteristics

Sociodemographic and clinical characteristics of T2DM patients with and without AS are presented in Tables 1a and 1b. Marital status, education level, employment status, and duration of diabetes were significantly associated with AS ($p < 0.05$), with higher prevalence observed among non-married, less educated, unemployed participants, and those with longer diabetes duration. Age and family setting showed no significant association.

Regarding anthropometric indices, abnormal BMI, WHR, WHtR, CI, ABSI, and skinfold thickness were significantly associated with higher AS prevalence ($p < 0.05$), with the strongest associations observed for WHtR, CI, and skinfold thickness. However, BAI showed no significant relationship with AS status.

Table 1a: Comparison of Sociodemographic and Medical Characteristics of T2DM Patients with and without Anxiety symptoms (n = 400)

Variables	AS (+) (n=200) F (%)	AS (-) (n=200) F (%)	χ^2 (df)	*P*-value
Sociodemographic characteristics				
Age (Years)				
20-39	31(15.5)	19(9.5)	3.92(3)	0.14
40-59	94(47.0)	93(46.5)		
>60	75(37.5)	88(44.0)		
Marital status				
Married	155(77.5)	164(82.0)	11.25(1)	0.003
Non married	45(22.5)	36(18.0)		
Level of education				
Non-formal education	91(45.5)	69(34.5)	8.20(4)	0.042
Primary education	62(31.0)	61(30.5)		
Secondary education	47(23.5)	69(34.5)		
Tertiary education	0(0.0)	1(0.5)		
Occupation				
Unemployed	80(51.0)	95(47.5)	9.26(1)	0.004
Employed	120(49.0)	105(52.5)		
Family setting				
Monogamy	91(45.5)	91(45.5)	0.44(2)	0.803
Polygamy	105(54.5)	109(54.5)		
Medical characteristic				
Diabetic duration				
<10 years	86(43.0)	89(45.5)	10.09(1)	0.022
>10 years	114(57.0)	111(55.5)		

AS (+): Anxiety symptoms present; AS (-): Anxiety symptoms absent

Table 1b: Comparison of Adiposity Characteristics of T2DM Patients with and without Anxiety symptoms (n = 400)

Variables	AS (+) (n=200) F (%)	AS (-) (n=200) F (%)	χ^2 (df)	*P*-value
Adiposity characteristics				
Body mass index				
Normal	47(23.5)	73(36.5)	8.05(1)	0.005
Abnormal	153(76.5)	127(63.5)		
Body adiposity index				
Normal	71(35.5)	81(40.5)	1.06(1)	0.303
Abnormal	129(64.5)	119(59.5)		
Waist-hip-ratio				
Normal	42(21.0)	80(40.0)	17.03(1)	0.001
Abnormal	158(79.0)	120(60.0)		
Waist-height-ratio				
Normal	42(21.0)	104(52.0)	41.46(1)	0.001
Abnormal	158(79.0)	96(48.0)		
Conicity index				
Normal	32(16.0)	111(55.5)	67.93(1)	0.001
Abnormal	168(84.0)	89(44.5)		
A body shape index				
Normal	71(35.5)	95(47.5)	5.93(1)	0.015
Abnormal	129(64.5)	105(52.5)		
Skin fold				
Normal	68(44.0)	138(69.0)	49.04(1)	0.001
Abnormal	132(66.0)	62(31.0)		

AS (+): Anxiety symptoms present; AS (-): Anxiety symptoms absent

Association between adiposity indices and anxiety symptom status among patients with T2DM

Multivariable logistic regression showed that the overall model was not statistically significant (Omnibus test: χ^2 = 11.294, df = 7, p = 0.126), with poor calibration indicated by a significant Hosmer–Lemeshow test (p = 0.004). Among the anthropometric variables, only TSF and BSF were significantly associated with AS. Higher TSF was associated with increased odds of anxiety symptoms (OR = 1.076, p = 0.026), while BSF showed a borderline inverse association (OR = 0.976, p = 0.043). Other indices, including WHR, CI, height, BAI, and weight, were not significant predictors of anxiety symptoms, suggesting limited explanatory value of anthropometric measures alone.

Table 2: Multivariable Logistic Regression Analysis of Anthropometric Predictors of Anxiety Symptoms Status with Model Fit Diagnostics

Variables in Equation	Omnibus Test		Hosmer and Lemeshow Test		Exp(B)	95% of C.I.		P-value
	χ^2 (df)	P value	χ^2 (df)	P value		Lower	Upper	
	11.294(7)	0.126	22.859(8)	0.004				
TSF					1.076	1.009	1.148	**0.026**
BSF					0.011	0.000	0.876	**0.043**
CI					7.345	0.156	346.131	0.310
WHR					0.976	0.910	1.047	0.504
Height					0.980	0.934	1.029	0.415
BAI					0.944	0.879	1.015	0.118
Weight					1.026	0.996	1.057	0.090

BAI: Body adiposity indices; WHR: Waist-to-hip ratio; CI: Conicity index; BSF: Bicep Skin fold ; TSF: Tricep Skin fold

Discriminatory performance of adiposity indices in identifying AS among T2DM

The ROC analysis demonstrates that all anthropometric predictors exhibited poor to marginal discriminative ability for anxiety classification, with AUC values clustering around the 0.50 threshold as depicted in figure 1 and table 3. Among the variables, TSF showed the highest but still weak discriminatory performance (AUC = 0.5737, 95% CI: 0.5112–0.6362, p = 0.0188), indicating a statistically significant yet clinically limited ability to distinguish anxiety cases from non-cases.

WHR and ABSI showed marginal performance (AUC = 0.5479 and 0.5383, respectively), but without statistical significance (p > 0.05), suggesting unstable predictive capacity. WHtR, CI, weight, BSF, BMI, height, and BAI all produced AUC values close to 0.50 with non-significant p-values, indicating performance comparable to random classification.

Table 3: Discriminatory Power of Different Adiposity Indices in Predicting AS Among T2DM Patients

Predictors	AUC	Std. Error	95% C. I	P-value
TSF	0.5737	0.03189	0.5112 to 0.6362	**0.0188**
WHR	0.5479	0.0307	0.4877 to 0.6081	0.1271
ABSI	0.5383	0.03105	0.4775 to 0.5992	0.222
WHtR	0.525	0.03156	0.4632 to 0.5869	0.4254
CI	0.5169	0.0313	0.4555 to 0.5782	0.5904
Weight	0.5167	0.03175	0.4545 to 0.5789	0.5946
BSF	0.5083	0.03172	0.4462 to 0.5705	0.7904
BMI	0.5078	0.03198	0.4451 to 0.5705	0.8045
Height	0.5042	0.03254	0.4404 to 0.5680	0.8931
BAI	0.5034	0.03067	0.4433 to 0.5635	0.914

AUC: Area under curve; BMI: Body mass index; BAI: Body adiposity indices; WHR: Waist-to-hip ratio; WHtR: Waist-to-height ratio; CI: Conicity index; ABSI: A body shape index; BSF: Bicep Skin fold; TSF: Tricep Skin fold

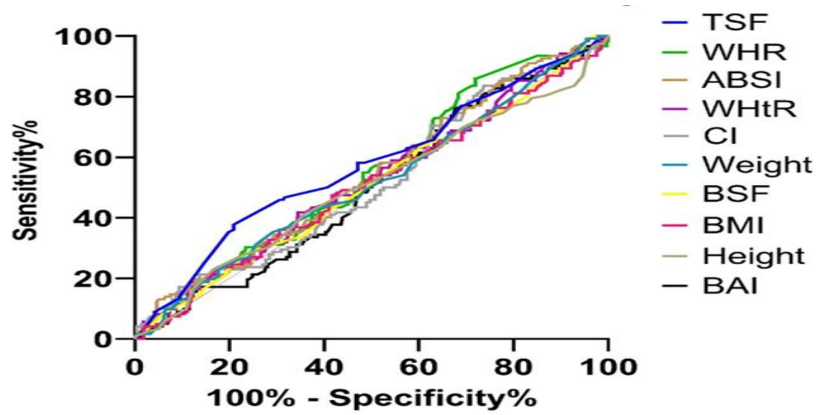

Figure 1: ROC for predicting AS from adiposity indices among T2DM. (BMI: Body mass index; BAI: Body adiposity indices; WHR: Waist-to-hip ratio; WHTR: Waist-to-height ratio; CI: Conicity index; ABSI: A body shape index; BSF: Bicep Skin fold; TSF: Tricep Skin fold)

The discriminatory performance of anthropometric variables for identifying anxiety status shows marked variability across sensitivity, specificity, and likelihood ratios (LR). WHR exhibited the highest sensitivity (86.07%), indicating strong ability to correctly identify individuals with anxiety; however, this was accompanied by low specificity (28.06%), reflecting a high false-positive rate. In contrast, TSF and ABSI demonstrated relatively higher specificity (79.14% and 94.96%, respectively), but lower sensitivity, indicating better rule-in than rule-out performance.

Positive predictive values (PPV) were moderate across variables, ranging from 52.99% to 72.23%, with ABSI and BAI showing the highest PPV (72.23%). Negative predictive values (NPV) remained relatively low and clustered around 52–67%, indicating limited ability to reliably exclude non-anxiety cases.

LR further confirm weak diagnostic utility, with LR+ values generally close to 1, suggesting minimal improvement over chance. ABSI and BAI showed comparatively higher LR+ (2.6012), indicating only modest discriminatory gain, while LR− values remained close to 1 across all variables, confirming poor rule-out capability.

Table 4: Discriminatory Performance of Anthropometric Indices for Classification of AS: Sensitivity, Specificity, Predictive Values, and Likelihood Ratios

Variable	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	LR+	LR-
TSF	37.7	79.14	64.378	55.953	1.8073	0.7872
WHR	86.07	28.06	54.471	66.825	1.1964	0.4964
ABSI	13.11	94.96	72.231	52.219	2.6012	0.9150
WHtR	41.8	65.47	54.762	52.939	1.2105	0.8890
CI	76.23	32.37	52.989	57.659	1.1272	0.7343
Weight	35.25	70.86	54.745	52.253	1.2097	0.9138
BSF	28.69	75.9	54.347	51.559	1.1905	0.9395
BMI	23.77	82.37	57.415	51.936	1.3483	0.9255
Height	22.95	83.45	58.101	51.994	1.3867	0.9233
BAI	13.11	94.96	72.231	52.219	2.6012	0.9150

BMI: Body mass index; BAI: Body adiposity indices; WHR: Waist-to-hip ratio; WHtR: Waist-to-height ratio; CI: Conicity index; ABSI: A body shape index; SF: Skin fold thickness; PPV: Positive predictive value; NPV: Negative predictive value; LR+: Positive likelihood ratio; LR-: Negative likelihood ratio

The Cut-Off Point of Anthropometric Variables in Predicting AS-risk

The ROC-derived optimal cut-off analysis indicates that all anthropometric variables exhibited low YI values (0.5034–0.5737)**,** reflecting limited overall diagnostic effectiveness for distinguishing anxiety status.

Among the variables, TSF demonstrated the highest discriminative performance with an optimal cut-off value of >15.10, yielding the maximum YI (0.5737), suggesting the best balance between sensitivity and specificity among all indices. WHR also showed moderate performance with an optimal threshold of <0.9995 (YI = 0.5479), followed by ABSI with a cut-off of <0.06940 (YI = 0.5383).

All remaining variables, including WHtR, CI, weight, BSF, BMI, height, and BAI, demonstrated YI values close to 0.50, indicating performance only slightly better than random classification.

Table 5: The Cut-Off Points of Anthropometric Variables in Predicting AS-Risk

Variable	Optimal Cut-off	Youden Index
TSF	> 15.10	0.5737
WHR	< 0.9995	0.5479
ABSI	< 0.06940	0.5383
WHtR	< 0.5250	0.525
CI	< 33.74	0.5169
Weight	> 74.50	0.5167
BSF	> 12.50	0.5083
BMI	< 23.13	0.5078
Height	< 152.5	0.5042
BAI	< 0.06940	0.5034

BMI: Body mass index; BAI: Body adiposity indices; WHR: Waist-to-hip ratio; WHtR: Waist-to-height ratio; CI: Conicity index; ABSI: A body shape index; SF: Skin fold thickness

Discussion

This study evaluated the association between multiple anthropometric adiposity indices and anxiety symptoms among patients with T2DM. The findings demonstrate that although some individual measures, particularly TSF, showed statistically significant associations, anthropometric indices collectively exhibited limited ability to differentiate individuals with and without anxiety symptoms. These findings suggest that anxiety symptoms among patients with T2DM are influenced by factors beyond body composition alone.

The results showed that anthropometric indices, when combined, did not significantly predict AS, indicating that the overall model lacked explanatory strength beyond chance. The significant Hosmer–Lemeshow test further suggested poor calibration between observed and predicted outcomes, implying that adiposity variables alone are insufficient to model the complexity of anxiety disorders in T2DM patients. Inferentially, this reflects the multifactorial nature of AS, which is influenced not only by metabolic status but also by neuroendocrine dysfunction, chronic stress exposure, inflammatory pathways, and psychosocial determinants that were not captured by anthropometric measures alone (Nameni *et al.,* 2024). Among individual predictors, only TSF showed a significant positive association with AS, suggesting that increased subcutaneous fat may contribute modestly to anxiety risk. This may be explained by the role of adipose tissue as an endocrine organ that secretes pro-inflammatory cytokines such as IL-6 and TNF-α, which have been implicated in neuroinflammation and mood dysregulation (Prodaniuc *et al.,* 2025 & Ouakinin *et al.,* 2018). BSF showed a borderline inverse association, although the confidence interval suggested instability, indicating that this effect may not be robust.

ROC analysis further confirmed the limited discriminative capacity of anthropometric indices, with AUC values, clustering around the 0.50 threshold, which represents random classification. TSF demonstrated the highest AUC, indicating only marginal discriminatory ability. WHR and ABSI showed weak performance, while WHtR, CI, BMI, weight, height, BSF, and BAI were essentially non-informative. The weak discriminatory performance observed across anthropometric indices highlights the complexity of psychological outcomes in chronic metabolic disease. Unlike cardiometabolic complications, anxiety symptoms are influenced by multiple interacting factors, including psychological stress, coping mechanisms, inflammatory processes, glycaemic control, social support, and socioeconomic circumstances (Harisu *et al.,* 2025). Therefore, body composition measures alone may not adequately capture the determinants of anxiety symptoms among individuals living with T2DM.

Discriminatory performance analysis showed marked variability in sensitivity, specificity, and likelihood ratios. WHR demonstrated high sensitivity (86.07%) but poor specificity (28.06%), indicating its limited value as a standalone diagnostic marker due to high false-positive rates. In contrast, TSF and ABSI showed higher specificity (79.14% and 94.96%, respectively) but low sensitivity, suggesting limited screening capability but slightly better rule-in potential. However, LR across all variables remained close to unity (LR+ ≈ 1.1–2.6; LR− ≈ 0.5–0.9), indicating minimal discriminatory gain over chance. These findings further confirm that anthropometric measures alone lack clinical utility in distinguishing AS status in T2DM patients (Gulzar *et al.,* 2025).

Cut-off analysis using the YI supported these observations, with values ranging from 0.5034 to 0.5737, indicating weak classification efficiency. TSF (>15.10) produced the highest YI (0.5737), followed by WHR (<0.9995) and ABSI (<0.06940), while all remaining indices clustered near 0.50, reflecting near-random classification performance. The poor performance of commonly used indices such as BMI and WHtR highlights their inability to capture fat distribution patterns relevant to neuropsychiatric outcomes (Chen *et al.,* 2025).

When compared with previous studies, these findings are largely consistent with reports from sub-Saharan Africa

(Agyemang *et al.,* 2026), Asia (Zhu *et al.,* 2020), and Europe (Liu *et al.,* 2020), which have shown that anthropometric indices are more strongly associated with cardiometabolic outcomes than psychological disorders. Some European studies have reported slightly stronger associations between WHR and mental health outcomes (Rindler *et al.,* 2023); however, these differences may be attributed to population heterogeneity, differences in fat distribution patterns, and variations in study design and adjustment for confounders (Huang *et al.,* 2020). The relatively weaker performance observed in this study may reflect the complex interplay between metabolic and psychosocial factors in African diabetic populations, where anxiety is strongly influenced by socioeconomic stress, healthcare access, and chronic disease burden rather than body composition alone (Boakye *et al.,* 2026).

Overall, the findings consistently demonstrate that while TSF shows a modest and repeated association across analytical approaches, anthropometric adiposity indices as a group have limited predictive and diagnostic value for AS in T2DM patients**.** This reinforces the need for integrated predictive models incorporating inflammatory markers, psychological factors, glycaemic control indicators, and socioeconomic variables to improve risk stratification and clinical utility in this population.

The findings of this study carry important clinical implications for the management of T2DM patients. Although most anthropometric indices demonstrated limited predictive power for AS, the modest association observed with TSF suggests that subcutaneous adiposity may serve as a supplementary marker for identifying individuals at slightly higher risk of anxiety. Clinicians should recognize that psychosocial and metabolic factors contribute substantially to AS in diabetic populations, and anthropometric measures alone are insufficient for screening or diagnosis. These results highlight the importance of integrating mental health assessments, such as standardized AS screening tools, into routine diabetes care, particularly for patients with long-standing disease, unemployment, lower education levels, or elevated subcutaneous fat, who may be at heightened vulnerability.

This study has several limitations. First, the cross-sectional design limits the ability to establish temporal or causal relationships between adiposity and anxiety symptoms. Second, participants were recruited from a single tertiary healthcare facility, which may limit the generalizability of findings to other populations. Third, the study relied primarily on anthropometric measures and did not include biochemical inflammatory markers, glycaemic control parameters, or detailed psychosocial assessments that may influence anxiety symptoms. Future longitudinal multicentre studies incorporating metabolic, inflammatory, and psychosocial variables are recommended.

CONCLUSION

Anthropometric adiposity indices demonstrate limited utility for identifying anxiety symptoms among patients with T2DM. Although TSF showed a modest association, most evaluated indices demonstrated poor discriminatory performance. These findings indicate that anthropometric measures alone are insufficient for assessing anxiety risk and should be complemented with psychological, metabolic, and socioeconomic assessments to improve understanding of mental health outcomes in diabetes care.

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